Integrating Quantitative Skills Across the Curriculum

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A Few Questions to Start

- What course do you teach that deal with quantitative reasoning?
- What skills are you trying to impart to students?
- What common problems do you have?
- What are you trying to accomplish at this seminar today?

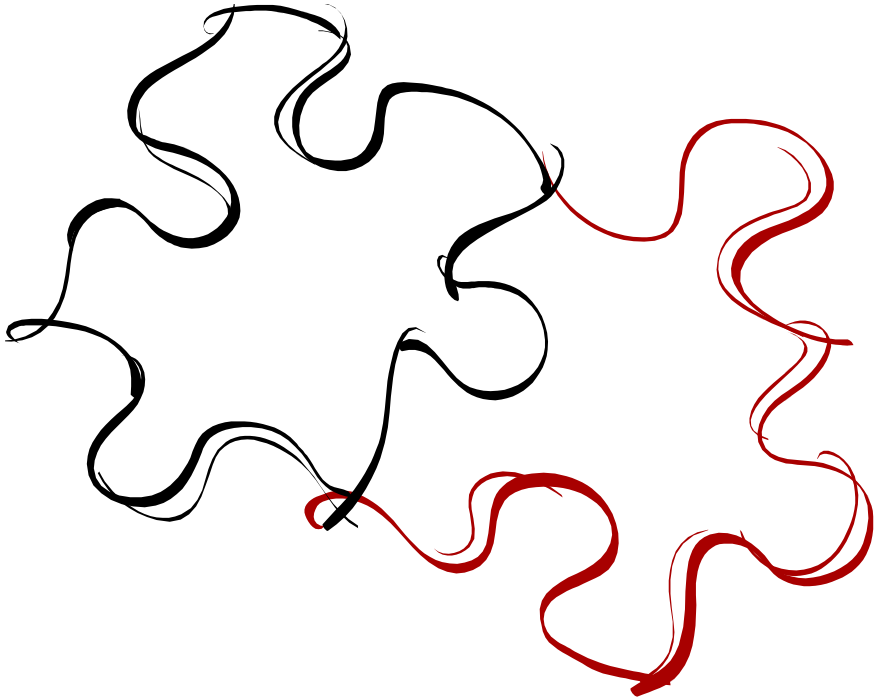
General Problem Solving Methods

Problem solving and critical thinking SKILLS are key

Problem Solving Requires Two Components:

1. Something to think about
   - Problem or topic
   - Facts and ideas they already know or can gather

2. A method or skill set to solve the problem
   - Critical Thinking
   - Creative Problem Solving
   - Another methodology



Every Discipline Has Its Own Skill Set

Examples:

- Dissection of a word problem
- Use of a one or more math equations
- Literary analysis
- Critique of an artistic work

- Many basic skills are shared and portable
    1. Critical Thinking
    2. Creative Problem Solving

Critical Thinking

Metaphysical

- Thinking about your own methods of thinking
  - Where does this fall on Bloom's Taxonomy?

Willingham – Combination of:

1. A person's existing knowledge
2. Information about a problem
3. Problem Solving skills

Why Don't Students Like School by Daniel Willingham

Ancient Wisdom

- Give a man a fish and he will eat for a day. Teach him how to fish and he will eat for a lifetime. (Chinese Proverb)

Critical Thinking Methods Example

Edward de Bono's deliberate thinking methods:

- AGO – Aims, Goals, Objectives
- CAF – Consider All Factors
- APC – Alternatives, Possibilities, Choices
- PMI – Plus, Minus, Interesting
- OPV – Other People's Views

Applying Critical Thinking to Problem Solving

Now that we know how to think constructively, how do we use it to solve problems?

Richard Feynman:

1. Write down the problem.
2. Think very hard.
3. Write down the answer.

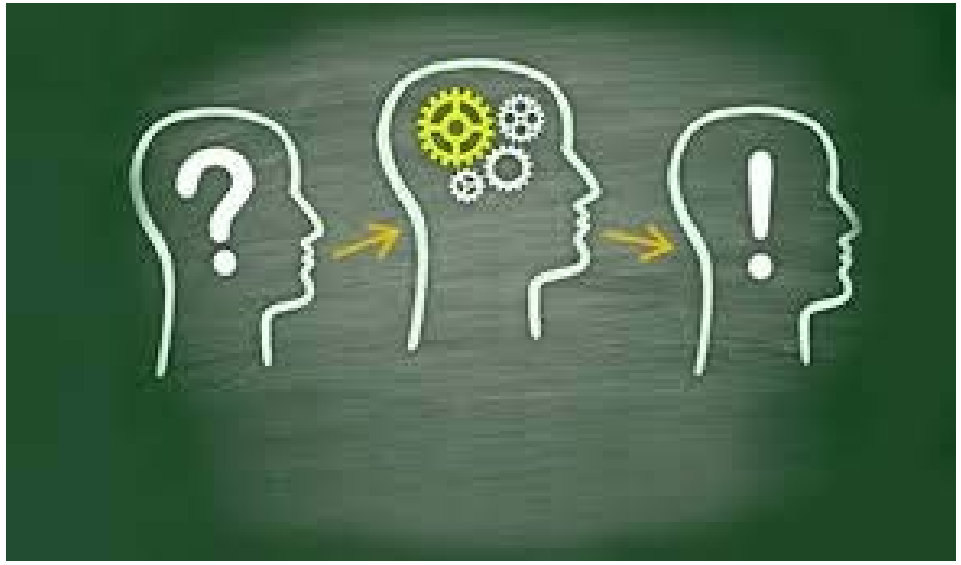
Holmesian (Deductive) Reasoning

"When you have eliminated the impossible, whatever remains, however improbable, must be the truth."

– Sherlock Holmes

- Observation
- Attention to detail
- Creative hypothesis generation
- Deductive reasoning

Types of Reasoning
(Problem Solving)



Deductive:

- Whole to part
- Hypothesis testing & Process of elimination

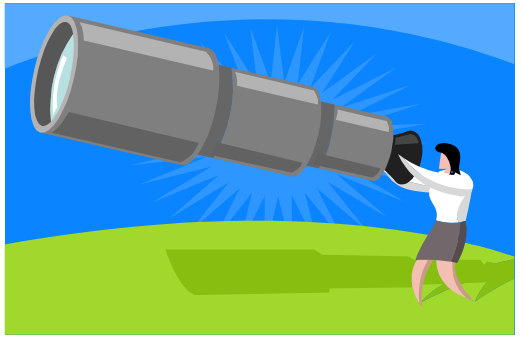
Inductive:

- Part to whole
- Generalizations & Inference

Creative:

- Systematic method of solution finding using logic & creativity
- As old as primates (maybe mammals)

Creative Problem Solving Process

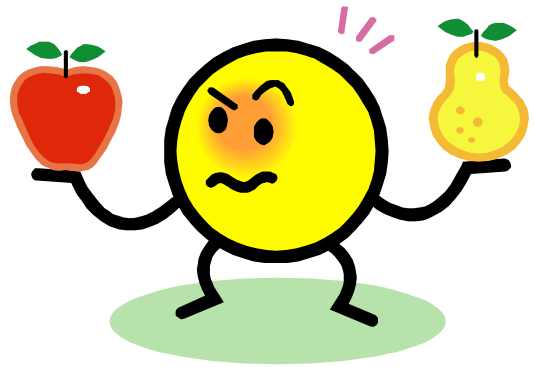


Explore the Challenge:

- Define objectives
- Collect the facts
- Clarify the problem

Generate ideas:

- Brainstorm
- Think outside the box



Solve:

- Choose the “best” solution
- Make a plan for action

Adapted from: Osborn-Parnes Creative problem solving process

Not as Ancient Wisdom

An essential aspect of creativity is not being afraid to fail.

– Isaac Newton

Creative Problem Solving Process

Explore the Challenge:

- Define objective
- Collect the Facts
- Clarify the problem

Generate ideas:

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Solve:

- Choose the “best” solution
- Make a plan for action

Rinse and Repeat as needed

(Trial and Error)

Formula for Invention

Trial + Error = Progress

Adapted from: Osborn-Parnes Creative problem solving process

Problem Solving is a Creative Process

When faced with an unfamiliar or difficult problem…try Creative Problem Solving methods:

1. **Draw a Diagram**
2. **Make a List**
3. **Brainstorm**
4. **Guess and check**
5. **Divide and conquer**
6. **Look for a Pattern**
7. **Work backwards** (start at the end)

Be Explicit About Teaching Relevant Skills

Effective Skill Development

- **Scaffolding** – show each part, then combine
- **Repetition** – once is never enough
- **Layer assignments** – build independence
  - Demo, mentored practice, independent practice, assessment
- **Assess, assess, assess** – repeated assessment with increasing stakes
  - Encourages practice and builds confidence

Paths to Success

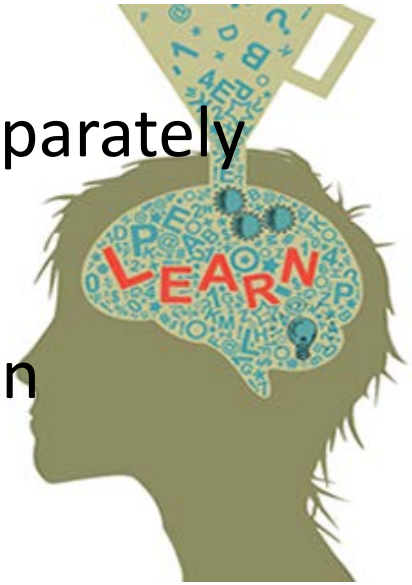
- Encourage students to analyze their own thinking
- Model methods of success
- The process may involve multiple steps
- Trial and error may be required

- Encourage students to be open to new methods
  - Embrace cognitive dissonance
  - Embrace new methods and adapt to the situation at hand

Creating an Atmosphere of Critical Thinking

Use Critical Thinking to Reinforce Quantitative Reasoning

- Retention of quantitative skills is improved when they are presented in context and they are used in open ended situations.
- Critical thinking experiences provide an opportunity to use hard skills in open ended situations.
- Hard skills can be modeled for students and evaluated separately from critical thinking experiences.
- Using critical thinking experiences requires establishing an atmosphere for critical thinking.



Effective Critical Thinking Experiences

1. Early & Often
2. “This is what we do”
3. Value is important

4. Assessment needs to be task appropriate
5. Encourage ideas & discourage discouragement

1 Early & Often

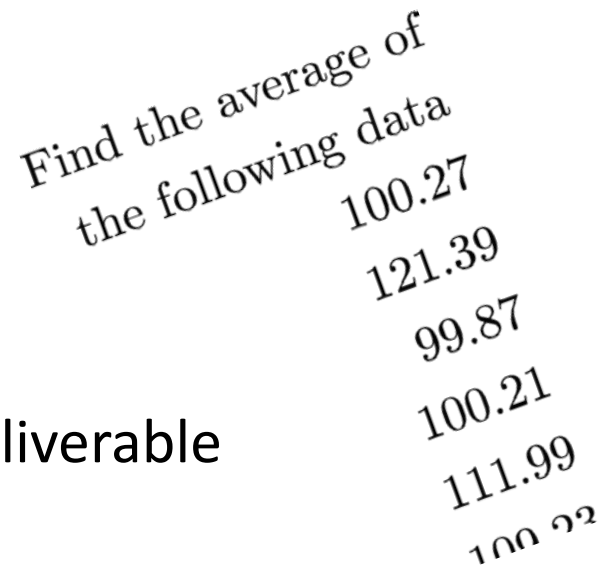
- CTEs need to be an unavoidable part of a course
- The should occur regularly during the semester, preferably according to some schedule
- CTEs have to be a part of a course early
  - Better in the first two class meetings
  - At least within the first two weeks

2 “This is what we do”

Open ended CTEs need to be treated like open ended CTEs

- Students need to work independently from the instructor
- The instructor needs to follow through with the experience, even if it’s floundering. (Don’t quit, adapt.)
- Students are responsible for solutions, not the instructor

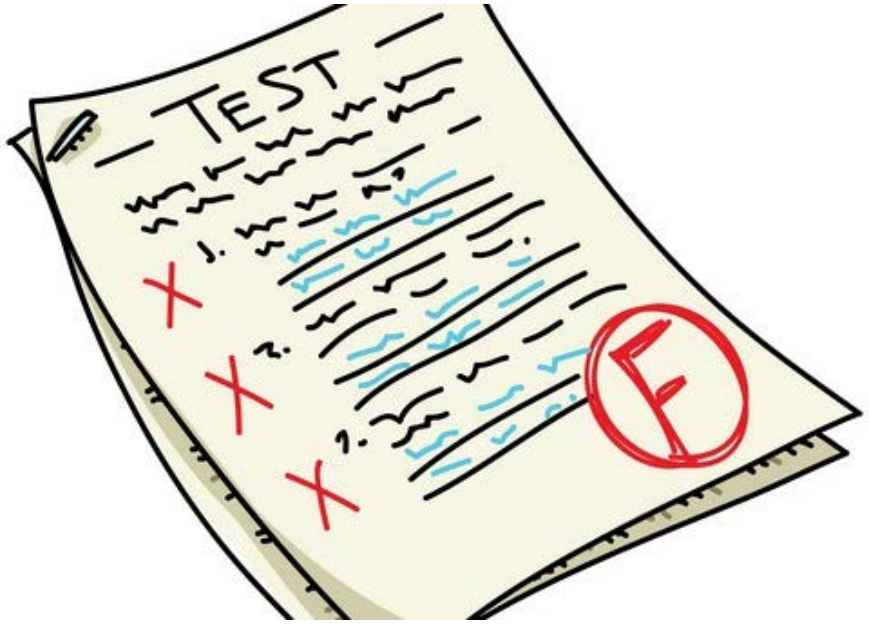
3 Value Is Important



- Critical thinking must be part of the grade
  - Try to assess the process separately from the deliverable
  - Try to promote productive creativity

- Assign things that students will find engaging and can't easily find solutions to
  - Don't waste time on mundane computation
  - Students can see through busy work

4 Task Appropriate Assessment



- CTEs should encompass hard skills and soft skills
- Grading hard skills too strictly may inhibit critical thinking
- Hard skills must be assessed to be reinforced
- Finding the right balance is key

5 Encourage Ideas

- Encouraging the process without criticism is necessary.

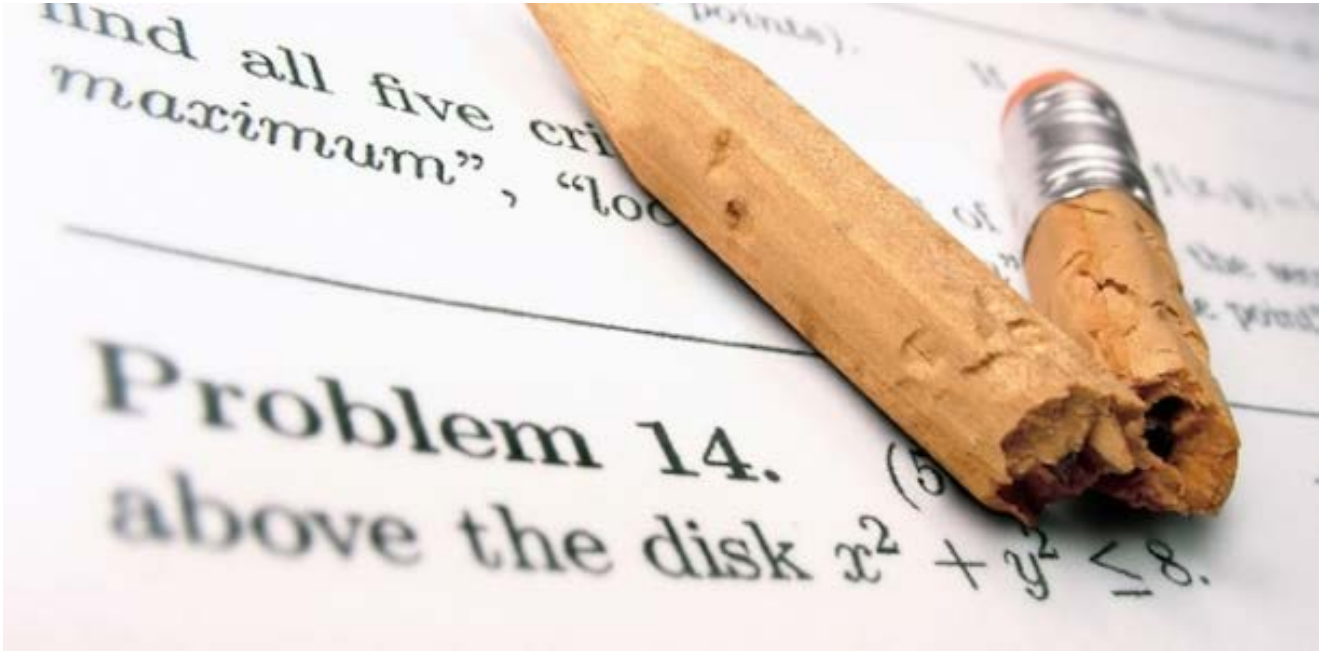
  "The most effective way to do it is to do it."-Emelia Earhart

- When working with students, try to comment on progress rather than correctness.

- Getting students to *do* without them being told *what to do* is hard.
  - Work with students to model good practices.
  - Students have to get used to, if not comfortable with, not knowing.
  - Offer enough structure to allow progress.

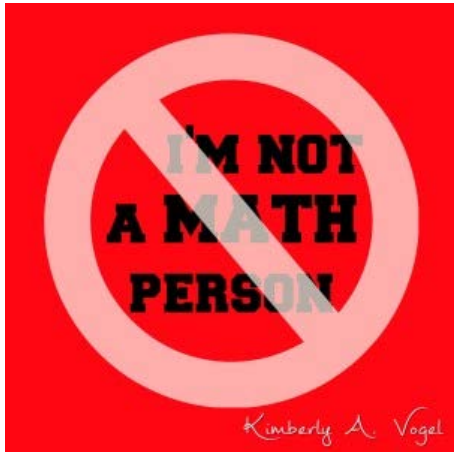
I’m not a math person

Dealing with math-phobes, math haters, and math anxiety



There's no such thing as a "math person"…

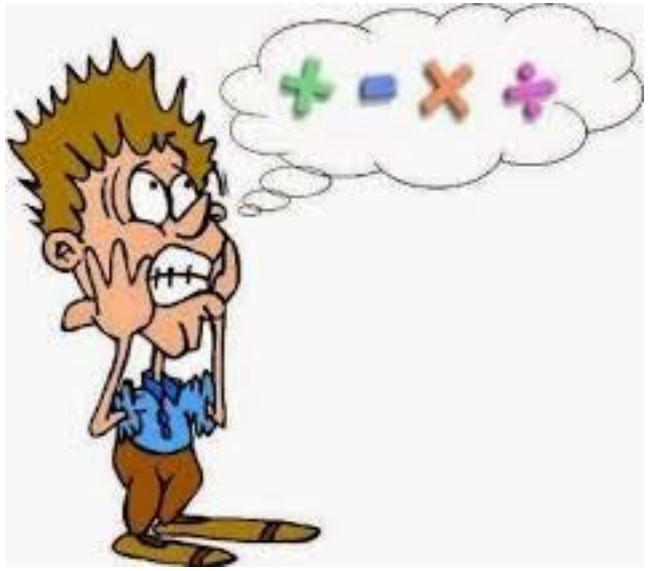
- Students often have a fixed mindset where mathematics and quantitative reasoning are concerned.



- Negative experiences in the past (along with reinforcement) lead many students to believe they're "bad at math" and can't improve.

- The reality is that with the right education and some effort, anyone can become proficient in mathematics and quantitative reasoning. (https://ww2.kqed.org/mindshift/2015/11/30/not-a-math-person-how-to-remove-obstacles-to-learning-math/)

…but math anxiety is real.



- The anxiety, frustration, and outright fear many students feel when dealing with quantities and procedures is very real.
- These feelings often stem from negative experiences in the past combined with reinforcement. Remember that students generally have 12 years of exposure to learning about math and quantity.
- Downplaying or dismissing these feelings does little to help students overcome them and start learning.

Dealing with math anxiety culturally

- Acknowledge student fears and discuss them openly
  - Students need to know they're not alone
- Avoid unhelpful dialog
  - "I was always bad at math", "I barely understand this", "This is hard for everyone"
- Promote a growth mindset
  - Try, fail, and try again.

Dealing with math anxiety practically

- Work with students to develop effective study habits.*
- Have students work with peers.
- Help students overcome “blank page syndrome”
- Be a model of good habits.
- Provide various models.

“You’re not bad at math. You’re bad at studying.”

- Students may fail to see that their poor performance may be tied to their study habits.
- Help students develop honest self-assessment methods.
- Teach students to find their mistakes and learn from them.
- Clearly articulate the time and process required to learn a skill.